IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

REQUEST FOR FILING NATIONAL PHASE OF PCT APPLICATION UNDER 35 U.S.C. 371 AND 37 CFR 1.494 OR 1.495

Hon. Commissioner of Patents
Washington, D.C. 20231

00909

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US)

Atty Dkt: P 290698 /M80260058
M# /Client Ref.

From: Pillsbury Winthrop LLP, IP Group:

Date: February 11, 2002

This is a **REQUEST** for FILING a PCT/USA National Phase Application based on:

1. International Application	2. International Filing Date	3. Earliest Priority Date Claimed
PCT/AU00/00959	11 August 2000	13 August 1999
⇧ country code	Day MONTH Year	Day MONTH Year (use item 2 if no earlier priority)

4. Measured from the earliest priority date in item 3, this PCT/USA National Phase Application Request is being filed within:

(a) ☐ 20 months from above item 3 date (b) ☒ 30 months from above item 3 date,

(c) Therefore, the due date (unextendable) is February 13, 2002

5. Title of Invention ANODE ASSEMBLY

6. Inventor(s) Vjekoslav JAKOVAC; Vladimir KANOVNIK; Drago JURIC

Applicant herewith submits the following under 35 U.S.C. 371 to effect filing:

7. ☒ Please immediately start national examination procedures (35 U.S.C. 371 (f)).

8. ☒ **A copy of the International Application** as filed (35 U.S.C. 371(c)(2)) is transmitted herewith (file if in English but, if in foreign language, file only if not transmitted to PTO by the International Bureau) including:

a. ☒ Request;
b. ☒ Abstract;
c. 21 pgs. Spec. and Claims;
d. 4 sheet(s) Drawing which are ☐ informal ☒ formal of size ☒ A4 ☒ 11"

9. ☒ **A copy of the International Application has been transmitted by the International Bureau.**

10. **A translation of the International Application** into English (35 U.S.C. 371(c)(2))

a. ☐ is transmitted herewith including: (1) ☐ Request; (2) ☐ Abstract;
(3) ______ pgs. Spec. and Claims;
(4) ______ sheet(s) Drawing which are:
☐ informal ☐ formal of size ☐ A4 ☐ 11"

b. ☐ is not required, as the application was filed in English.

c. ☐ is not herewith, but will be filed when required by the forthcoming PTO Missing Requirements Notice per Rule 494(c) if box 4(a) is X'd or Rule 495(c) if box 4(b) is X'd.

d. ☐ Translation verification attached (not required now).

11. ☒ Please see the attached Preliminary Amendment

12. ☐ Amendments to the claims of the International Application **under PCT Article 19 (35 U.S.C. 371(c)(3)), i.e., before 18th month from first priority date above in item 3, are transmitted herewith (file only if in English) including:**

13. ☒ PCT Article 19 claim amendments (if any) have been transmitted by the International Bureau

14. ☐ Translation of the amendments to the claims **under PCT Article 19 (35 U.S.C. 371(c)(3)), i.e., of claim amendments** made before 18th month, **is attached (required by 20th month from the date in item 3 if box 4(a) above is X'd, or 30th month if box 4(b) is X'd, or else amendments will be considered canceled).**

15. **A declaration of the inventor** (35 U.S.C. 371(c)(4))
a. ☐ is submitted herewith ☐ Original ☐ Facsimile/Copy
b. ☒ is not herewith, but will be filed when required by the forthcoming PTO Missing Requirements Notice per Rule 494(c) if box 4(a) is X'd or Rule 495(c) if box 4(b) is X'd.

16. **An International Search Report (ISR):**
a. Was prepared by ☐ European Patent Office ☐ Japanese Patent Office ☒ Other
b. ☒ has been transmitted by the international Bureau to PTO.
c. ☒ copy herewith (1 pg(s).) ☒ plus Annex of family members (1 pg(s).).

17. **International Preliminary Examination Report** (IPER):
a. ☒ has been transmitted (if this letter is filed after 28 months from date in item 3) in English by the International Bureau with Annexes (if any) in original language.
b. ☒ copy herewith in English.
c.1 ☒ IPER Annex(es) in original language ("Annexes" are amendments made to claims/spec/drawings during Examination) including attached amended:
c.2 ☐ Specification/claim pages #_____ claims #_____
Dwg Sheets #_____
d. ☐ Translation of Annex(es) to IPER **(required by 30th month due date, or else annexed amendments will be considered canceled).**

18. **Information Disclosure Statement** including:
a. ☐ Attached Form PTO-1449 listing documents
b. ☐ Attached copies of documents listed on Form PTO-1449
c. ☒ A concise explanation of relevance of ISR references is given in the ISR.

19. ☐ **Assignment** document and Cover Sheet for recording are attached. Please mail the recorded assignment document back to the person whose signature, name and address appear at the end of this letter.

20. ☐ Copy of Power to IA agent.

21. ☐ **Drawings** (complete only if 8d or 10a(4) not completed): ___ sheet(s) per set: ☐ 1 set informal; ☐ Formal of size ☐ A4 ☐ 11"

22. Small Entity Status ☐ is **Not** claimed ☒ is claimed (**pre**-filing confirmation required)
22(a) _____ (No.) Small Entity Statement(s) enclosed (since 9/8/00 Small Entity Statements(s) not essential to make claim)

23. **Priority** is hereby claimed under 35 U.S.C. 119/365 based on the priority claim and the certified copy, both filed in the International Application during the international stage based on the filing in (country) _____ of:

	Application No.	Filing Date		Application No.	Filing Date
(1)	PQ2188	August 13, 1999	(2)		
(3)			(4)		
(5)			(6)		

a. ☒ See Form PCT/IB/304 sent to US/DO with copy of priority documents. If copy has not been received, please proceed promptly to obtain same from the IB.
b. ☐ Copy of Form PCT/IB/304 attached.

RE: USA National Phase Filing of PCT/AU00/00959

JC13 Rec'd PCT/PTO 11 FEB 2002

24. Attached:

25 Per Item 17.c2, **cancel original** pages #_____, claims #_____, Drawing Sheets #______

26. **Calculation of the U.S. National Fee (35 U.S.C. 371 (c)(1)) and other fees is as follows:**
Based on amended claim(s) per above item(s) ☐ 12, ☐ 14, ☐ 17, ☐ 25 (hilite)

Total Effective Claims	minus 20 =	x $18/$9	=	$	966/967
Independent Claims	minus 3 =	x $84/$42	=	$	964/965
If any proper (ignore improper) Multiple Dependent claim is present,		add$280/$140		+0	968/969

BASIC NATIONAL FEE (37 CFR 1.492(a)(1)-(4)): →→ **BASIC FEE REQUIRED, NOW** →→→→

A. If country code letters in item 1 are **not** "US","BR","BB","TT","MX","IL" "NZ", "IN" or "ZA"

See item 16 re:

1. Search Report was not prepared by EPO or JPO ---------	add$1,040/$520		960/961
2. Search Report was prepared by EPO or JPO ------------	add$890/$445	+520	970/971

SKIP B, C, D AND E UNLESS country code letters in item 1 are "US","BR","BB","TT","MX","IL", "NZ", "IN", "ZA", "LC" or "PH"

(X) (only) (one) (of) (these) (4) (boxes)

→ ☐ B. If USPTO did not issue both International Search Report (ISR) and (if box 4(b) above is X'd) the International Examination Report (IPER), -------------------	add$1,040/$520	+0	960/961
→ ☐ C. If USPTO issued ISR but not IPER (or box 4(a) above is X'd), ----------------------------------	add$740/$370	+0	958/959
→ ☐ D. If USPTO issued IPER but IPER Sec. V boxes not all 3 YES, ----------------------------------	add$710/$355	+0	956/957
→ ☐ E. If international preliminary examination fee was paid to USPTO and Rules 492(a)(4) and 496(b) satisfied (in IPER Sec. V all 3 boxes must be YES for all claims), --	add $100/$50	+0	962/963

27. **SUBTOTAL =** $520

28. If Assignment box 19 above is X'd, add Assignment Recording fee of ----$40 +0 (581)

29. If box 15a is x'd, determine whether inventorship on Declaration is different than in international stage. If yes, add (per Rule 497(d) ----$130 +0 (098)

30. Attached is a check to cover the ------------------------ **TOTAL FEES** $520

Our Deposit Account No. 03-3975
Our Order No. 7287 (C#) | 290698 (M#)

00909

CHARGE STATEMENT: The Commissioner is hereby authorized to charge any fee specifically authorized hereafter, or any missing or insufficient fee(s) filed, or asserted to be filed, or which should have been filed herewith or concerning any paper filed hereafter, and which may be required under Rules 16-18 and 492 (missing or insufficient fee only) now or hereafter relative to this application and the resulting Official document under Rule 20, or credit any overpayment, to our Account/Order Nos. shown above for which purpose a duplicate copy of this sheet is attached.
This CHARGE STATEMENT does not authorize charge of the issue fee until/unless an issue fee transmittal form is filed

Pillsbury Winthrop LLP
Intellectual Property Group

By Atty: Glenn J. Perry **Reg. No.** 28458

Sig: [signature] **Fax:** (703) 905-2500
Tel: (703) 905-2161

Atty/Sec: gjp/vaw

NOTE: File in duplicate with 2 postcard receipts (PAT-103) & attachments.

10/049242
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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re PATENT APPLICATION OF

Inventor(s): JAKOVAC et al.

Filed: Herewith

Title: ANODE ASSEMBLY

February 11, 2002

PRELIMINARY AMENDMENT

Hon. Commissioner of Patents
Washington, D.C. 20231

10049242 .051502

Sir:

Please amend this application as follows:

IN THE SPECIFICATION:

At the top of the first page, just under the title, insert

☒ --This application is the National Phase of International Application PCT/AU00/00959 filed August 11, 2000 which designated the U.S. and that International Application

☒ was ☐ was not published under PCT Article 21(2) in English.--

Respectfully submitted,

PILLSBURY WINTHROP LLP
Intellectual Property Group

By: [signature]
Attorney: Glenn J. Perry
Reg. No: 28458
Tel. No.: (703) 905-2161
Fax No.: (703) 905-2500

Atty\Sec. GJP/vw
1600 Tysons Boulevard
McLean, VA 22102

(703) 905-2000

APPLICATION UNDER UNITED STATES PATENT LAWS

Atty. Dkt. No. PW 290698
(M#)

Invention: ANODE ASSEMBLY

Inventor (s): Vjekoslav JAKOVAC
Vladimir KANOVNIK
Drago JURIC

00909
Pillsbury Winthrop LLP

This is a:

- ☐ Provisional Application
- ☐ Regular Utility Application
- ☐ Continuing Application
  - ☐ The contents of the parent are incorporated by reference
- ☒ PCT National Phase Application
- ☐ Design Application
- ☐ Reissue Application
- ☐ Plant Application
- ☐ Substitute Specification
  Sub. Spec Filed ____
  in App. No. ____/____
- ☐ Marked up Specification re
  Sub. Spec. filed ____
  In App. No ____/____

SPECIFICATION

10/049242
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ANODE ASSEMBLY

Field of the Invention

This invention relates to an anode assembly for an electrolytic metal smelting cell and is particularly suited to the electrolytic refining of aluminium from alumina.

Background of the Invention and Prior Art

The majority of the world aluminium production takes place in electrolytic smelting cells employing the Hall-Heroult Process. In this process direct current is passed through a molten salt bath at a temperature of approximately 970°C in which alumina is dissolved. The bath consists of a mixture of fluoride salts in which the main component is cryolite (Na_3AlF_6). As the electrolysis takes place in a molten salt at a high temperature in a corrosive environment, the service conditions for various electrical components of the electrolytic cell are arduous.

The molten bath in which the alumina is dissolved is contained within an electrolytic cell. The typical electrolytic cell comprises a rectangular steel shell lined with refractory materials as insulation, and carbon on the hot face. The carbon blocks on the bottom of the cell contain embedded conductors for the collection of current and act as the cathode. Carbon anodes are suspended from above the cell and dip into the bath. Metallic conductors, known as anode assemblies or anode rods provide the mechanical support and carry the current to the anodes. The current design of the anode assembly is based on a steel structure attached to a carbon anode block. The steel structure is connected to the electrical bus bar via a copper or aluminium bar. The overall electrical resistance of a conventional anode assembly comprises the anode bar ohmic resistance, the steel structure (yoke) ohmic resistance and transition resistance between the steel structure and the anode bar.

During cell operation the bath is kept molten by the heat generated by the passage of electric current. The anodes are covered by a mixture of alumina and crushed bath to protect the anodes, particularly the connection points between the assemblies and carbon from airburn. During the process, oxygen is released

at the anodes where it reacts with carbon to produce mainly CO_2 gas and release small amounts of CO and SO_2.

In order to add alumina to the cell, the protective crust is first broken and the alumina added through the hole in the crust. As the fresh alumina contains a small amount of moisture in t he alumina, fluorides and chlorides in the molten bath releasing a cocktail of gases (SO_2, CHI an HF) which at elevated temperatures can be highly corrosive with respect to anode assemblies. The CO_2 gas released at the electrolytic face is highly oxidising with respect to the consumption of carbon on the sides of the anode and on the hot faces of the anode which are exposed to the pot atmosphere below the crust and ore cover. This consumption of carbon from the anode sides reduces the life of the cell and represents an additional cost to the process.

Conventional aluminium reduction plants require a large infrastructure, typically costing above US$4000 per tonne of installed capacity and a large amount of electrical energy and carbon. The arduous service conditions within the cell impose expensive maintenance requirements on pots and anode assemblies. By increasing the production capacity of the existing plants and reducing the consumption of electrical energy and carbon and by reducing the need for anode assembly maintenance, a reduction of cost of aluminium production can be achieved.

An improvement on the conventional anode assembly is shown in US 5538607. US Patent No. 5538607 discloses an anode assembly comprising an anode bar of high electrically conductive material. The end of a leg of the anode bar is received within a steel sleeve or stub and the stub inserted into a carbon anode block. While the anode assembly of US 5538607, in theory is able to provide a high electrically conductive anode assembly which is easily maintained, the design does not address the practical problems faced in the application of an electrolytic cell such as oxygen burn out or anode block submersion.

Summary of the Invention

The present invention is directed to an anode assembly construction for supporting anodes particularly adapted for use in the existing Hall-Heroult cell applications.

Accordingly the invention provides an anode assembly for conducting electrical energy to an anode of an electrolytic smelting cell comprising an anode bar of high electrically conductive material, a yoke electrically connected to said anode bar, and anode stubs fitted to the ends of said yoke, said yoke comprising a core of highly electrically and thermally conductive material and an outer structural sheath extending at least over the ends of said core, said outer structural sheath having substantially the same thermal expansion characteristics as the core material over the operating range of temperatures of said anode assembly.

The yoke of the anode assembly of the present invention is preferably formed from a core material of high electrical and thermal conductivity such as high purity copper nickel or aluminium. Accordingly, the electrical and thermal conductivities of the core materials are preferably with the range of 5-70 ($1/\mu\Omega m$) and 80-400 W/mK respectively An outer protective sheath of high temperature structural material with substantially thermal expansion properties, such as austenitic or ferritic stainless steels spheroidal graphitic iron and carbon steel preferably extends over at least the ends of the core

The materials of the core and sheath are said to have substantially the same thermal expansion properties when the net expansion of both materials as a result of heating to operating temperature can be absorbed by elastic deformation of the materials with no loss of contact thermally or electrically between the materials.

By having the sheath material and core made of material having substantially the same thermal expansion properties, the metals can expand at approximately the same rate over the range of operating temperatures of the anode assembly in the smelting cells. This enables the good electrical contact between the sheath and core to be maintained ensuring a high possible current

density to the anode during operation. It also enables good thermal conduction contact to be maintained allowing heat to be conducted away from the anode block.

The applicants have found that by having the core and sheath formed of materials with substantially the same thermal expansion characteristics over the operating range of temperatures, the combination of the resulting strain of the materials (due to expansion) at operating temperature and the maximum yield stress can be accommodated within the system whilst avoiding plastic deformation or differential movement. This may be accomplished by selecting core and sheath materials which have a differential co-efficient of thermal expansion of less than 4 x 10^{-6} m/mk and preferably controlling the strain to maintain the maximum stress to below the yield stress of the weaker material. It is intended that a differential co-efficient of thermal expansion of less than 4 x 10^{-6} m/mk is within the scope of substantially the same thermal expansion characteristics in the context of the invention. Controlling the maximum service temperature can preferably limit the strain to less then 0.2%.

In a preferred form of the invention, the outer protective sheath extends over substantially the length of the yoke. The yoke which is preferably U-shaped and the core sealed within the outer protective sheath. The sheath material provides the high temperature strength and resistance to hot corrosive gases, and the core material, free from mechanical duties. As stated earlier maintaining good thermal and electrical contact between the components particularly the core and sheath provides for conduction and distribution of current from the assembly to the carbòn and heat from the carbon to the pot atmosphere. Furthermore, the internal joins and electrical contact interfaces between the conductive core and outer sheath are completely protected from ingress of oxygen and other corrosive gases preferably by welding the core within the sheath.

The lower part of the assembly which is in intimate contact with the carbon anode block preferably consists of stubs having a larger diameter to the yoke. These stubs may have a thicker sheath, which serves to distribute the

current across the interface and to act as a thermal insulator. In this way the amount of heat extracted from the process can be controlled and the core having a lower melting temperature protected from extreme temperatures which occur when an anode is incorrectly set, or slips in the clamp. Furthermore there may be a thermally insulating disc inside the stub at the bottom of the core, whose function is to further control process heat incursion by having heat flow only through the sides of the stubs.

"Dropped" anodes are known to be the main causes of anode "burn-offs" in the electrolytic refining process. Burn-offs occur when an anode draws a high current, well above its normal current, and generates so much heat internally that the cast iron thimble or stub, which secures the carbon block to the assembly, melts (1100°C) and the anode separates. Burn-offs represent a major disturbance to the process requiring unscheduled anode changes and usually result in anode assembly damage.

The strategy commonly used in burn-off prevention is based on using electrical signal noise (pot noise) to detect possible existence of dropped anodes. The control system responds to this problem through a sequence of automatic responses. When this sequence is exhausted an alarm is raised and manual intervention requested. Depending on the work flow and other activities, pot operators may respond immediately, or in due course. The usual operator response is to manually check all anode assemblies in the pot in order to detect the problem anode and to action it. If the dropped anode is detected sufficiently early, the anode can be raised and no further damage is sustained. If however the burn-off threshold of the anode is low, it usually burns off by the time the alarm is raised. Therefore to reduce the incidence of burn-offs, the problem anodes must have a high burn-off threshold. The magnitude of a disturbance due to a "dropped" anode must be sufficiently large (high current draw by one anode) to be identified as a possible anode problem and such high current drawing anodes must survive under this stressed high current condition long enough, for the problem to be corrected. By maintaining good thermal contact between the components of the anode assembly over the range of operating

temperatures, heat can be conducted away from anode block and stubs at a much faster rate than would be the case if gaps were to appear between the components due to thermal expansion. Hence the anode assembly of the present invention is designed to have a much higher burn-off threshold and a much higher assembly damage threshold, when compared to conventional anode assemblies.

In a preferred form of the invention, the yoke is substantially U-shaped. The yoke is preferably formed from a round rod, made of a material with a high electrical and a high thermal conductivity, inserted into a thin walled sheath of corrosion resistant material, which has a high temperature strength. Electrical grade copper is the preferred conductor material, whereas various grades of stainless steel are preferred sheath material, although mild steel or high carbon boiler tube can be used. The sheath (or in some cases the copper rod) maybe tapered on both ends and metallised with a brazing compound before being assembled. The anode assembly may further comprise stubs, which receive the tapered ends of the yoke. The stubs are preferably of tubular construction and have a receiving taper machined into them. This taper is designed to achieve compression of contact surfaces and leave a gap between the bottom of the stub and the bottom of the core. The yoke is pressed into the stubs with a very high load (>100 tonnes), which results in the compression of the joints between the core and sheath and between the sheath and stubs which also assists in maintaining contact between the components during heating. The combination of pressure and taper are designed to achieve a partial expansion of the stubs. The tops of the stubs are then secured to the sheath by welding.

The pressed assembly then may be preheated in a furnace and the previously sprayed brazing compound wets and spreads over all contact surfaces and thus, under capillary action, achieves filling and sealing of any interfacial gaps. This creates an excellent electrical contact and achieves the exclusion of oxygen from contact surfaces. A metal plug may be provided to close the bottom of the stub and an insulating disc made of compressed ceramic fibre insulation may be placed into the space between the core and the metal plug.

The stub bottom then may be sealed by circumferential welding of the plug to the stub. Alternatively, an air gap can be left below the core in the stub to also provide insulation.

As with the contact between the core and the sheath, it is highly desirable for the sheath and the stubs to be formed from materials which have substantially the same thermal expansion characteristics over the operating ranges. Accordingly, the differential co-efficient of thermal expansion between materials preferably does not exceed 4 x 10^{-6} m/mk.

In accordance with another aspect of the invention, there is provided the anode assembly of claim 24 wherein the core (29) is produced from a metal having electrical and thermal conductivities in the ranges of 5-70 ($1/\mu\Omega m$) and 80-400 W/mK respectively.

By providing an anode assembly in which the contacting metals are compatible, stepped changes in characteristics can be attained between the materials of the core and the sheath and the sheath and the stubs allowing the use of materials in the core and the stubs which otherwise would not have been compatible under the operating conditions.

In order to provide mechanical strength and toughness to the assembly a flared protective structural collar extends over the stems of the anode rod and secured to the sheath of the yoke. The collar allows a certain degree of flexing in the yoke, but resists plastic deformation. The collar may be attached to the conductive anode stems by mechanical indentation and secured by means such as welding. Mechanical indentation provides a mechanical anchorage of the assembly in case of weld failure and at the same time reduces stress on welds to reduce the likelihood of such failure. The securement of the collar to the yoke seals the yoke and excludes the possibility of oxygen ingress from the top.

In the conventional anode assembly, the yoke is of a rigid construction, usually made from cast steel, and depending on its size and operating temperature, can either cause the carbon blocks to crack or result in yielding and plastic deformation of high temperature softened, mild steel stubs. This plastic deformation of the assembly increases with each cycle, leading to problems with

stub toe-in. This requires the conventional anode assemblies to be periodically refurbished to re-set, or replace the stubs. The high temperature in the stubs sometimes causes them to extrude, becoming longer and thinner over time. This also has a negative impact on assembly performance and increases the anode assembly maintenance costs. Furthermore anode assemblies in which the stubs are either thinned down or miss-aligned with the anode stub-hole have higher electrical losses due to the reduction in the contact area with the stubs. This invention addresses the problem of stub deformation and deterioration by providing a highly conductive core to transport the heat away from the stubs and by providing insulation to control the heat flow into the stubs. This way the stub temperature can be maintained in the region where plastic deformation and chemical attack can be kept to a minimum.

Preferably the top of the yoke is provided with a groove which extends into the high electrically conducting core. This groove is designed to reduce the rigidity of the yoke. The anode rod consisting of a main anode stem and at least one auxiliary anode stem is received and secured within the groove to provide electrical contact with the core of the yoke. The main anode stem is designed to be clamped into the existing anode clamps and fit into the existing anode handling equipment. The auxiliary stem is shorter and extends from below the clamps to the yoke. The auxiliary stem is preferably welded to the main stem at its top and to the yoke at its bottom. This structure, with a deep groove and dual rod construction, is elastic and it is capable of flexing to accommodate any miss match in thermal expansion between the assembly and the carbon block, without resulting in permanent deformation.

As the carbon anode is progressively consumed during electrolysis, the top and the sides of the anode are also partially consumed by air ingress under the ore cover and by CO_2 gas released during electrolysis. This non-electrolytic consumption of carbon not only increases the anode consumption, but also exposes the stubs to a possible exposure to molten bath. In some cases, as the anodes reach the end of their useful life and the cell has a high bath height, the anode butt can become completely submerged below the surface of the bath. In

this case the top part of stubs become exposed to the molten bath and can be easily attacked by bath. The progressive dissolution of stubs damages the anode assembly, thus requiring costly maintenance and at the same time contaminates the metal produced with iron. Although the raw materials typically used in the production of aluminium contain less than 100 ppm of iron, a typical smelter produces a aluminium metal with an iron content between 0.1 and 0.2 wt. %. Most of this iron comes from anode assemblies either via formation of scale, which separates and mixes with the recycled bath or via flux wash (dissolution attack) of anode stubs.

The thermal and heat generation properties of the anode assembly of the present invention may be adjusted to exclude the possibility of flux wash even under the conditions of fully submerged anode operation. The heat extraction through the highly conductive core cools the top of the anode which reduces the amount of airburn and the possibility of stub exposure to a molten bath. Furthermore the heat extraction cools the exposed stubs to a temperature which ensures that even if the stubs were completely submerged below the surface of molten bath, a frozen cryolite ledge will form on the exposed surfaces and prevent flux wash.

In some instances, it may be preferable for the yoke to be provided without an outer protective sheath. Under these circumstances the high electrically and thermally conducting core is inserted directly into the stub of the anode.

According to this aspect of the invention, there is provided an anode assembly for conducting electrical energy to an anode of an electrolytic smelting cell comprising an anode bar of high electrically conductive material, a yoke comprising a core of highly electrically and thermally conductive material electrically and thermally connected to said anode bar, said yoke being received within anode stubs which are receivable within recesses formed in an anode block, said yoke and said stubs having substantially the same thermal expansion characteristics over the operating range of temperatures of said anode assembly.

In another aspect. the invention further provides a method of forming an anode assembly comprising the steps of forming a yoke having a high electrically and thermally conductive core and an outer structural sleeve extending at least over the ends of said core, said outer structural sheath having substantially the same thermal expansion characteristics as said core over the operating range of temperatures of said anode assembly, forming a groove in said yoke, and connecting an anode bar of highly electrically conductive material to said yoke in electrical contact with the core of said yoke.

In some instances, the applicants have found that high thermal and electrical contact between the sheath and the stubs can be maintained over the operating range of the anode assembly simply by forming a taper at the ends of the sheath and a complimentary tapered bore in the stubs. According to this aspect of the invention, there is provided an anode assembly (17) for conducting electrical energy to an anode of an electrolytic smelting cell comprising an anode bar (20) of high electrically conductive material connected to a yoke (21), the ends of the yoke (21) being receivable within anode stubs (22), said anode stubs (22) being received within said anode(C), said yoke (21) comprising a core (29) of highly electrically and thermally conductive material and an outer structural sheath (30) characterised in that the outer structural sheath (30) extends substantially the length of the yoke (21), the ends of the yoke (21) being tapered to be received within complimentary bore in said stubs (22).

The invention is also directed to a smelting cell incorporating the anode assembly described above connected to an anode beam for conducting electrical energy to the anode assembly.

The anode assembly of the present invention is able to increase the production capacity and power efficiency in existing cells through innovative anode assembly construction, better process heat extraction and more efficient use and conversion of raw materials. The anode assemblies, are substantially maintenance free and virtually process indestructible. In situations of extreme process excursions and damage, the anode assemblies of the present invention are best handled by specialised refurbishment or recycling of high value

materials. These assemblies are designed to prevent being damaged and not necessarily for ease of repair of the damaged components.

Brief Description of the Drawings

Figure 1 is a schematic sectional view taken through a Hall-Heroult smelting cell and illustrates the anode assembly of the present invention;

Figure 2 is an exploded view of the anode assembly in accordance with the present invention;

Figure 3(a) is a sectional view of the anode assembly below line 3-3 of Figure 2;

Figure 3(b) is a sectional view of the stubs 22 shown in Figure 3(a);

Figure 3(c) is a sectional view of the yoke 29 shown in Figure 3(a);

Figure 4 is a cross sectional view of the upper part of the anode assembly in accordance with the invention;

Figure 5 is an output from a thermoelectric model showing a typical temperature distribution in a conventional anode assembly under submerged conditions; and

Figure 6 is an output from a thermoelectric model showing a typical temperature distribution in an anode assembly of present invention under submerged conditions.

Description of the Preferred Embodiments

An aluminium reduction cell 10 for commercial production of aluminium is illustrated in Figure 1 illustrating the use of the anode assembly in accordance with the invention.

The electrolytic cell 10 is defined by an exterior shall 11 lined internally with insulation 12. A cathode collector bar 13 is connected to the cathode bus bar 14 (negative source of power) and embedded in cathode block 15. Molten aluminium A is contained within the walls of the cell 16 covered by a frozen cryolite ledge L. In the molten electrolyte E and within which at least partly immersed and suspended from above are one or more carbon blocks C which are attached to the anode assemblies 17 of the present invention. Solidified alumina and cryolite S cover the anodes C and form a crust. The anode

assemblies are connected to the anode ring bus 18 (positive source of power) via anode clamps 19. The steel shell 11 of the electrolytic cell 10 is covered by conventional gas collection hood H.

Electricity is conducted to the carbon block C by an anode assembly of the present invention which is generally designated by the reference numeral 17 and specifically adapted for use during the production of aluminium via the Hall-Heroult process.

Referring to Figure 2, the anode assembly includes an anode rod having a main anode stem 20, which is usually made of copper or aluminium and generally rectangular configuration as can be seen in Figure 2. The anode rod is attached through main anode bar 20 to the yoke 21. The yoke comprises a core of high electrically conductive material and an outer structural sheath extending substantially the length of the yoke 21. The outer structural sheath is preferably a high temperature structural material with similar thermal expansion properties such as austenitic stainless steel. The yoke 21 supports tow hollow stubs 22 which contain an insulating disc 23 and are sealed on the bottom by a welded plug 24. As shown in Figures 2 and 3 the ends of the yoke are slightly tapered and metallised with a brazing compound 25. During assembly the yoke is placed into a special pressing jig (not shown) and pressed into the stubs to cause their partial expansion. A deep groove 26 is milled into the top of the yoke to enable the main stem 20 and the auxiliary anode stem 27 to be electrically connected to the core of the yoke 29. Both stems may be covered by a protective collar preferably of stainless steel which is flared at its bottom and welded to the yoke and to the stems.

Details of electrical and mechanical connection between the yoke 21 and stub 22 is shown in Figure 3. The electrical connection between the steel stub 22 and the electrically conductive core 29 of the yoke 21 occurs via a tapered pressure fit between the outer protective sheath 30 and the machined tapered hole in the stub 31. The mechanical connection between the steel stub 22 and the yoke 21 is preferably made via a weld 32. To enhance the electrical connection and to reduce the friction during pressing operation, the outer

surface 25 of the tapered part of the yoke can be metallised with a brazing compound. On subsequent heat treatment, the brazing compound melts and reacts with the mating surfaces of the stub and the tapered part of the yoke, thus enhancing the electrical connection and excluding the possibility of contact deterioration due to oxygen ingress. The separation of mechanical and electrical functions ensures that the weld on top of the stub is not weakened by the passage of current and the generation of heat. Similarly any deterioration of the quality of the welded joint between the yoke and the stubs will not result in deterioration of electrical performance of the assembly. The reduced perimeter area of the arms of the yoke combined with the highly conductive core impart cooling to the top of the stub which enables it to operate in bath under submerged conditions without suffering from stub wash.

Details of the anode rod to yoke connection are illustrated in Figure 4. The main anode stem 20 of the anode rod is first bevelled for welding and inserted into the milled grove on top of the yoke. The main stem is welded to the yoke core 29 on both sides with a full penetration fillet weld 33. This is followed by insertion and welding of the auxiliary stem 27, which is welded only on one side. A specially fitting flared protective collar 28 is slipped over both rods and welded to the outer protective sheath 30 of the yoke 21 and the top 35 of the auxiliary stem 27. The auxiliary stem is welded to the main anode stem with a full penetration fillet weld 36. The dual stem construction and the weakened structure of the yoke due to the presence of a deep grove, combined with the flared protective collar provide for inward flexing of the arms 37, 38 of the yoke 21 without leading to permanent deformation. This flexing absorbs the miss-match of the thermal expansion between the yoke 21 and anode carbon black without placing undue stress on the block.

Thermoelectric modelling results of a conventional anode assembly are shown in Figure 5. These results illustrate that if a conventional anode assembly was to be operated such that the anode was submerged under molten bath stub 22 would be attacked. It shows that with molten bath E flooding over the top of the carbon C, the stub 22 would reach a temperature at the point of exposure 37 which is above the melting point of the bath (955°C). Stub attack and erosion would be inevitable under these conditions.

The results of thermoelectric modelling of an anode fitted with an assembly of present invention are shown in Figure 6. Due to the increased conduction of heat away from the stubs 32 which occurs with the anode assembly of the invention, the results illustrate that if an anode assembly according to the present invention was used to operate an anode so that it is submerged under bath, the stub of such an assembly would not be attacked. It shows that a frozen cryolite ledge L would form on the carbon anode C surrounding the stub 22 and thus protecting the stub from any attack. The maximum temperature reached of a stub attached to an anode assembly of present invention under such conditions is 825°C. which is over 100°C below the melting point of bath E.

For the preferred copper core, stainless steel sheath combination, the thermal and electrical conductivity properties in the typical temperature range of 200°C to 550°C are as follows:-

<u>Thermal conductivity</u>

Copper : 300-360 (W/mk)
Stainless steel : 18-25 (W/mk)

<u>Electrical conductivity</u>

Copper : 25-28 ($1/\mu\Omega m$)
Stainless steel : 0.9-1.1 ($1/\mu\Omega m$)

Co-efficient of thermal expansion

Copper : 17.8×10^{-6} mm/mmk
Stainless steel : 14.6×10^{-6} mm/mmk

Table 1

Normal Operation		Existing		Present invention 70 mm ins	90 mm ins	90 mm unins.
Anode Amperage	kA	5.1	6	6	6	6
Max Anode rod Temp	°C	311	323	231	216	230
Gusset Temp	°C	397	443	248	230	245
Ave Stub Temp	°C	752	808	542	476	463
Max Cu/Stub Temp	°C	808	868	496	420	477
Anode Top Temp	°C	789	839	663	627	619
Anode resistance	micro. ohm	78.0	77.7	59.8	53.7	53.1
Net Carbon	kgC/kgAl	0.463	0.490	0.412	0.403	0.401
Anode Power Loss	kW	2.0	2.8	2.0	1.9	1.9
Anode Heat Extraction	kW	2.4	2.6	3.4	3.8	

Table 1 shows the summary of thermoelectric and reaction modelling comparing anode assemblies of the present invention with existing anode assemblies during normal operation. The results show that the present invention has the capacity to reduce the maximum service temperature of the critical components of the assembly by 100 to 200°C. This reduces the heat stress and chemical damage an assembly is likely to suffer during normal operations. It also shows that the maximum anode top temperature could be reduced from the present 800°C to less than 650°C. This reduction in temperature would reduce carbon consumption by more than 10 % by virtually eliminating all redundant carbon consumption. The results also predict that an anode fitted with an anode assembly of present invention would have a much lower electrical voltage loss (2 kW cf. 2.8 kW) and a much greater process heat extraction capability (4.2 vs. 2.4 kW). This means that the production of aluminium could be made more efficient due to reduced electrical losses and the production process could be intensified as the anode assembly had additional capacity to dissipate process heat.

Table 2

Submarine		Existing		Present invention 70 mm ins	90 mm ins	90 mm unins.
Max Anode rod Temp	°C	339	346	320	393	392
Gusset Temp	°C	476	485	349	428	428
Ave Stub Temp	°C	963	971	883	890	885
Max Cu/Stub Temp	°C	985	997	862	868	892
Equivalent Heat Loss	kW	3.7	3.7	6.3	8	8
Stub wash superheat	°C	11.1	10.1	25.6	27.4	26.2

Table 2 shows the summary of results of thermoelectric modelling comparing the anode assemblies of the present invention with existing anode assemblies during submerged operation. These modelling results show that only the anode assemblies of the present invention have the capacity to continue to operate in a submerged mode of operation. The modelling results predict that the conventional anode assemblies if submerged under liquid bath would suffer stub wash if the bath operating temperature of the cell was more that 10°C above its liquidus temperature. As most cells operate with a superheat approaching 15°C, conventional anode assemblies are not capable of continued operation under submerged conditions. In cases where it happens by accident or as a result of excessive carbon airburn leading to exposure of stubs, the anode assemblies become damaged and require costly stub replacement.

The modelling predicts that the minimum superheat required to cause stub wash on the anode assembly of the present invention is above 25°C. As such a high superheat during normal cell operation is very rare, the anode assemblies of the present invention are unlikely to suffer damage as a result of normal process excursions.

Table 3

Burn off		Existing	Present invention 70 mm ins	90 mm ins	90 mm unins.
Amperage	kA	8.4	14.0	18.1	15.6
Ave Stub Temp	°C	1009	952	962	932
Max Cu Temp	°C	1048	924	929	958
Stub wash superheat	°C	3.1	20.6	23.5	23.2
Max Anode Rod Temp	°C	505	343	390	387
Gusset Temp	°C	610	362	421	419

Table 3 shows the results of thermoelectric modelling comparing existing anode assemblies with the present invention during anode burn-off; the most stressful condition which may exist in an aluminium reduction cell. This occurs when an anode burn-off occurs. The modelling results predict that a conventional anode would burn off if its normal current leading was increased by 50%. At that point the average stub temperature would be well above the melting point of the bath, and a burn off would most probably lead to anode assembly damage. The results of modelling for the anode assemblies of the present invention, show that the burn-off threshold is much higher (14 to 18 kA cf. 8.4kA). The critical superheat for stub wash is also predicted to remain above 20°C. This suggests that the anode assembly of the present invention, due to the specificity of its construction, would resist damage even under the most stressful of situations.

The present invention is able to provide a high performance, low maintenance anode assembly suitable for use in aluminium reduction cells. The high electrical and thermal performance was achieved through the use of a highly electrically conductive core inside a protective sheath and the use of a totally sealed design which excludes possibility for oxygen penetration of contact surfaces. Further the electrical performance was enhanced though use of high pressure contacts and brazed joints.

The present invention is able to achieve low maintenance by encasing all hot components of the assembly in a heat and chemically resistant protective sheath. Further, its mechanical robustness was enhanced through separation of the electrical and mechanical functions of the assembly such that mechanical joins are not additionally stressed by heat generated by the passage of current and electrical joins do not suffer as a result of mechanical failure.

The innovative use of ceramic fibre insulation in the stub had an additional benefit when it was accidentally discovered that the burn off threshold of the anode assembly was increased despite reduced heat losses.

CLAIMS

1. An anode assembly (17) for conducting electrical energy to an anode (22) of an electrolytic smelting cell comprising an anode bar (20) of high electrically conductive material, a yoke (21) electrically connected to said anode bar (20), and anode stubs (22) fitted to the ends of said yoke (21), said yoke comprising a core (29) of highly electrically and thermally conductive material and an outer structural sheath (30) extending at least over the ends of said core (29), said outer structural sheath (30) having substantially the same thermal expansion characteristics as the core over the operating range of temperatures of said anode assembly.

2. The anode assembly of claim 1 wherein a high thermal and electrically conductive contact is maintained between the core and sheath over the operating range of temperatures of said anode assembly.

3. The anode assembly of claim 1 or 2 wherein the core (29) is produced from a metal having electrical and thermal conductivities in the ranges of 5-70 ($1/\mu\Omega m$) and 80-400 W/mK respectively

4. The anode assembly of claim 3 wherein the core (29) and sheath (30) are produced from a combination of metals whose differential coefficient of thermal expansion does not exceed 4×10^{-6} m/mK.

5. The anode assembly of claim 3 wherein the core (29) is produced from a material selected from the group of high purity, aluminium, copper and nickel.

6. The anode assembly of claim 4 wherein the sheath (30) is produced from a material selected from the group of austenitic or ferritic stainless steels, spheroidal graphite iron and carbon steel.

7. The anode assembly according to claim 1 wherein the yoke (21) is substantially U-shaped and the outer protective sheath (30) extends substantially the length of said core.

8. The anode assembly according to claim 1 wherein the outer structural sheath has substantially the same thermal expansion characteristics as the stubs over the operating range of temperatures of the anode assembly.

9. The anode assembly according to claim 1 or 8 wherein the ends of the yoke (21) are tapered, the anode stubs being provided with a tapered bore for receiving the tapered ends of said yoke.

10. The anode assembly according to claim 7 wherein the anode bar comprises a main anode stem and an auxiliary anode stem, the auxiliary stem extending substantially the length of the structural collar of the anode bar.

11. The anode assembly of claim 10 wherein the auxiliary anode stem and the main anode stem are secured together, the auxiliary anode stem being sealed within the outer protective collar and the main anode stem extending from said collar for connection to an anode bus bar.

12. The anode assembly according to claim 1 wherein an air gap or an insulating plug is maintained in the bore of said anode stub below said yoke when the yoke is pressed into said stubs.

13. The anode assembly according to claim 1 wherein the outer sheath of the yoke and the protective collar are formed from a high temperature structural austenitic steel.

14. A method of forming an anode assembly comprising the steps of forming a yoke (21) having a high electrically and thermally conductive core (29) and an outer structural sheath (30) extending at least over the ends of said core (29), said outer structural sheath (30) having substantially the same thermal expansion characteristics as said core (29) over the operating range of temperatures of said anode assembly, forming a groove in said yoke, and connecting an anode bar (20) of highly electrically conductive material to said yoke (21) in electrical contact with the core (29) of said yoke (21).

15. The method of claim 14 wherein the core is produced from a material having electrical and thermal conductivities in the ranges of 5-70 ($1/\mu\Omega m$) and 80-400 W/mK respectively

16 The method of claim 10 wherein the yoke is formed in a substantially U-shaped configuration the outer structural sheath of the yoke extends substantially the length of said core.

17. The method of claim 16 further including the step of securing a structural collar to the outer structural sheath of said yoke such that the anode bar extends through said collar.

18. The method of claim 17 wherein the outer protective collar surrounding said anode rod is sealed.

19. The method claim 18 wherein the yoke is initially pressed into protective anode stubs, said stubs being able to be pressed into recesses formed in the anode where the anode assembly is press fitted into said anode.

20. The method of claim 19 wherein a taper is formed in the ends of the yoke to compliment a tapered bore formed in the anode stubs, the stubs being secured to the ends of the yoke by press forming the ends into the anode stubs.

21. The method of claim 20 wherein the anode stubs are provided with a plug and an insulating disc between the plug and the ends of the yoke when the yoke is pressed into the anode stubs.

22. The method of claim 20 wherein an air gap exists between the ends of the lower most part of the stubs when the yoke is pressed into the anode stubs.

23. The method of claim 13 wherein the core and sheath are produced from a combination of materials whose differential co-efficient of thermal expansion does not exceed 4×10^{-6} m/mK

24. An anode assembly (17) for conducting electrical energy to an anode of an electrolytic smelting cell comprising an anode bar (20) of high electrically conductive material, a yoke (21) comprising a core (29) of highly electrically and thermally conductive material electrically and thermally connected to said anode bar, said yoke (21) being received within anode stubs (22) which are receivable within recesses formed in an anode block, said yoke (21) and said stubs (22) having substantially the same thermal expansion characteristics over the operating range of temperatures of said anode assembly.

25. The anode assembly of claim 24 wherein the core (29) is produced from a metal having electrical and thermal conductivities in the ranges of 5-70 ($1/\mu\Omega$m) and 80-400 W/mK respectively.

26. The anode assembly of claim 24 wherein the yoke (21) and the stubs (22) are produced from a combination of metals whose differential co-efficient of thermal expansion does not exceed 4 x 10^{-6} m/mK.

27. The anode assembly according to claim 26 wherein the ends of the yoke (21) are tapered, the recesses in the anode stubs being provided with a tapered bore for receiving the tapered ends of said yoke.

28. An anode assembly (17) for conducting electrical energy to an anode of an electrolytic smelting cell comprising an anode bar (20) of high electrically conductive material connected to a yoke (21), the ends of the yoke (21) being receivable within anode stubs (22), said anode stubs (22) being received within said anode(C), said yoke (21) comprising a core (29) of highly electrically and thermally conductive material and an outer structural sheath (30) characterised in that the outer structural sheath (30) extends substantially the length of the yoke (21), the ends of the yoke (21) being tapered to be received within complimentary bore in said stubs (22).

29. The anode assembly of claim 28, further characterised by the anode rod (20) being provided with a protective structural collar secured to the outer structural sheath of the yoke.

30. The anode assembly of claim 28 further characterised by the outer structural sheath (30) being of a material having substantially the same thermal expansion characteristics as the core over the operating range of temperatures of said anode assembly.

31. A smelting cell comprising an anode assembly of claim 1 or 28, and an anode beam connected to said anode assembly for conducting electrical energy to the anode bar of said anode assembly.

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(71) Applicant *(for all designated States except US)*: **SRA TECHNOLOGIES PTY LTD** [AU/AU]; Suite G9, 62 Wellington Parade, East Melbourne, VIC 3002 (AU).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **JAKOVAC, Vjekoslav** [AU/AU]; 31 Kalbar Road, Research, VIC 3095 (AU). **KANOVNIK, Vladimir** [AU/AU]; 2/55 Blackwood Street, Carnegie, VIC 3163 (AU). **JURIC, Drago** [AU/AU]; 6 Ben Nevis Grove, Bulleen, VIC 3105 (AU).

(74) Agent: **FREEHILLS CARTER SMITH BEADLE**; 101 Collins Street, Melbourne, VIC 3000 (AU).

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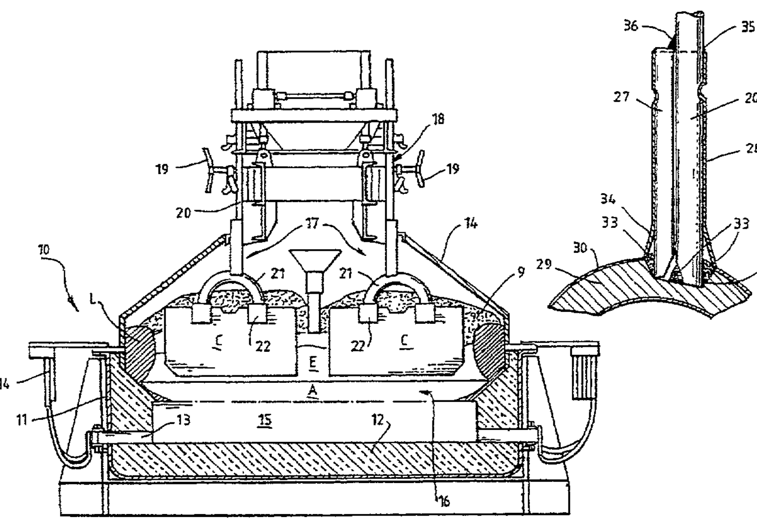
For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: ANODE ASSEMBLY



(57) Abstract: An anode assembly (20) for conducting electrical energy to an electrolytic smelting cell comprising an anode (C) of high electrically conductive material connected to a yoke (21), the ends of the yoke (21) being receivable within anodes, said yoke comprising a core (29) of highly electrically conductive material and an outer structural sheath (30) extending substantially the length of the yoke, the anode rod being in electrical contact with the core of the yoke (21) and provided with a protective structural collar secured to the outer structural sheath of the yoke (21). In order for the electrical and thermal contact between the core (29) and sheath (30) to be maintained, the differential co-efficient of thermal expansion over the operating temperature range of the assembly is preferably substantially the same or within 4 x 10^{-6} m/mk.

WO 01/12881 A1

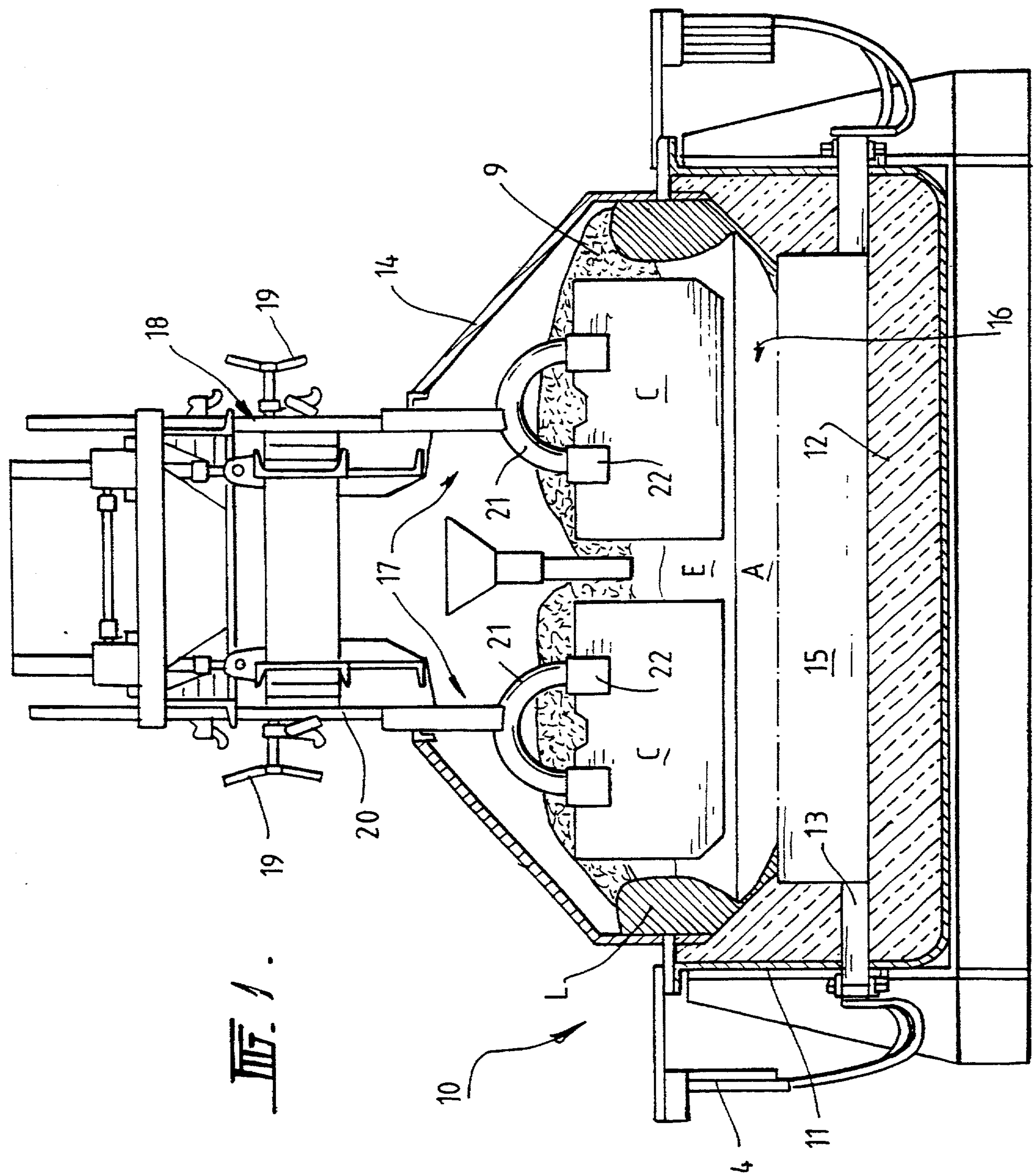


FIG. 1.

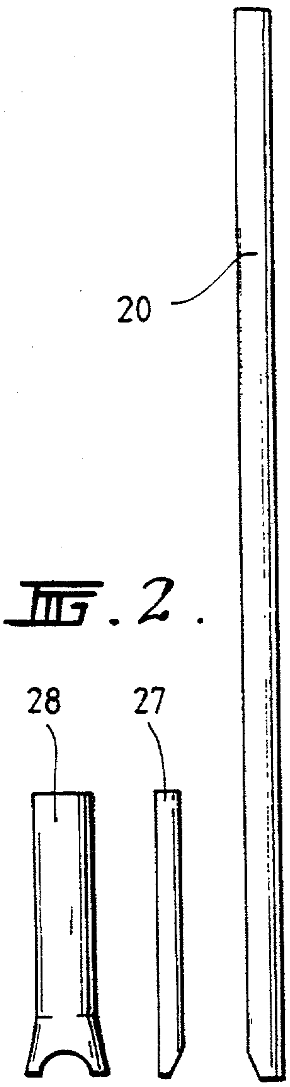


FIG. 2.

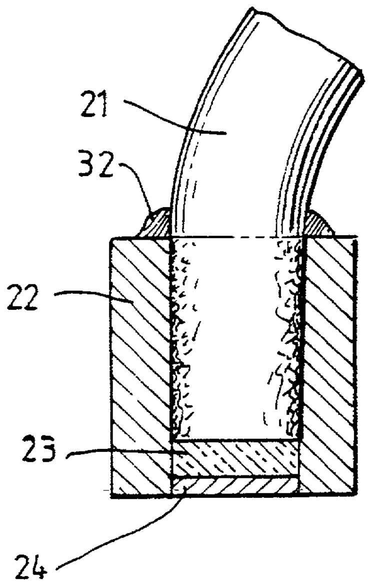


FIG. 3a.

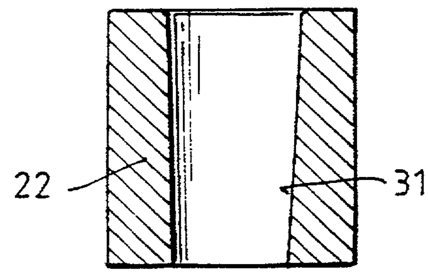


FIG. 3b.

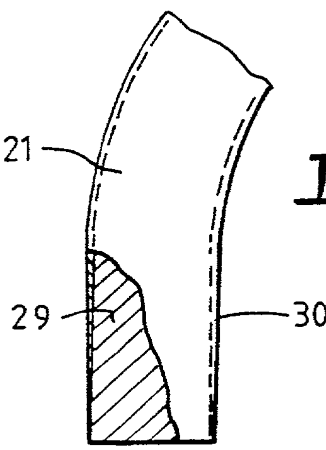
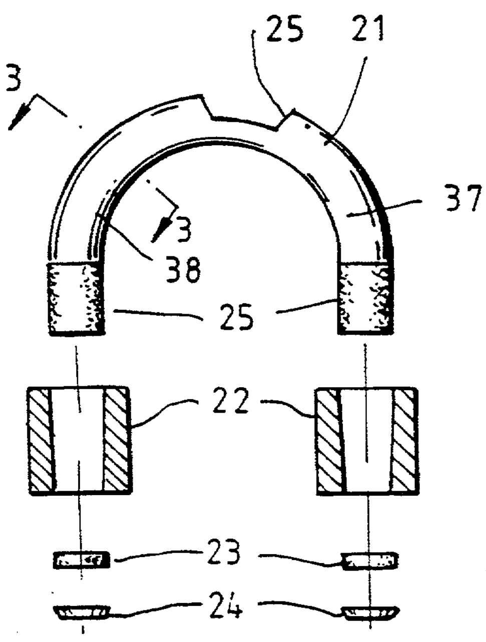


FIG. 3c.



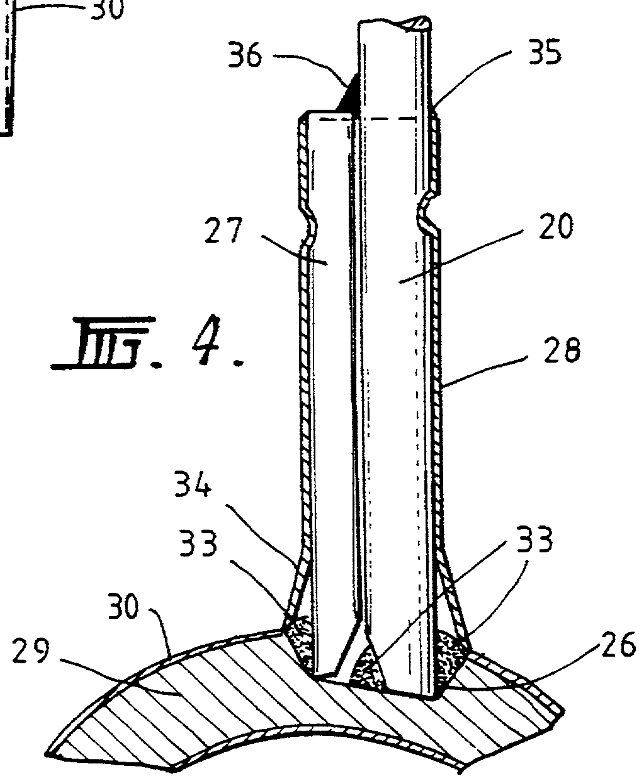


FIG. 4.

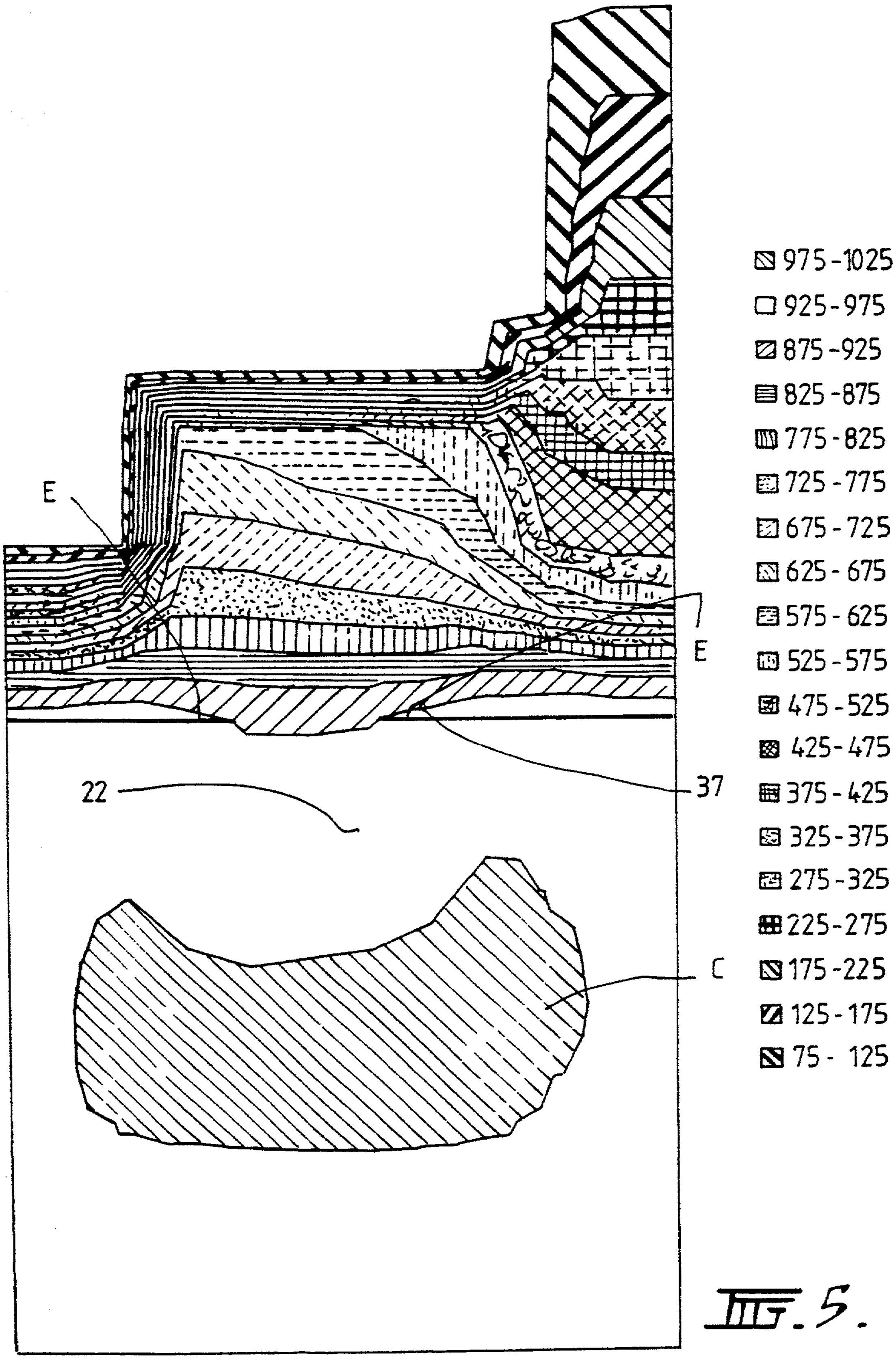

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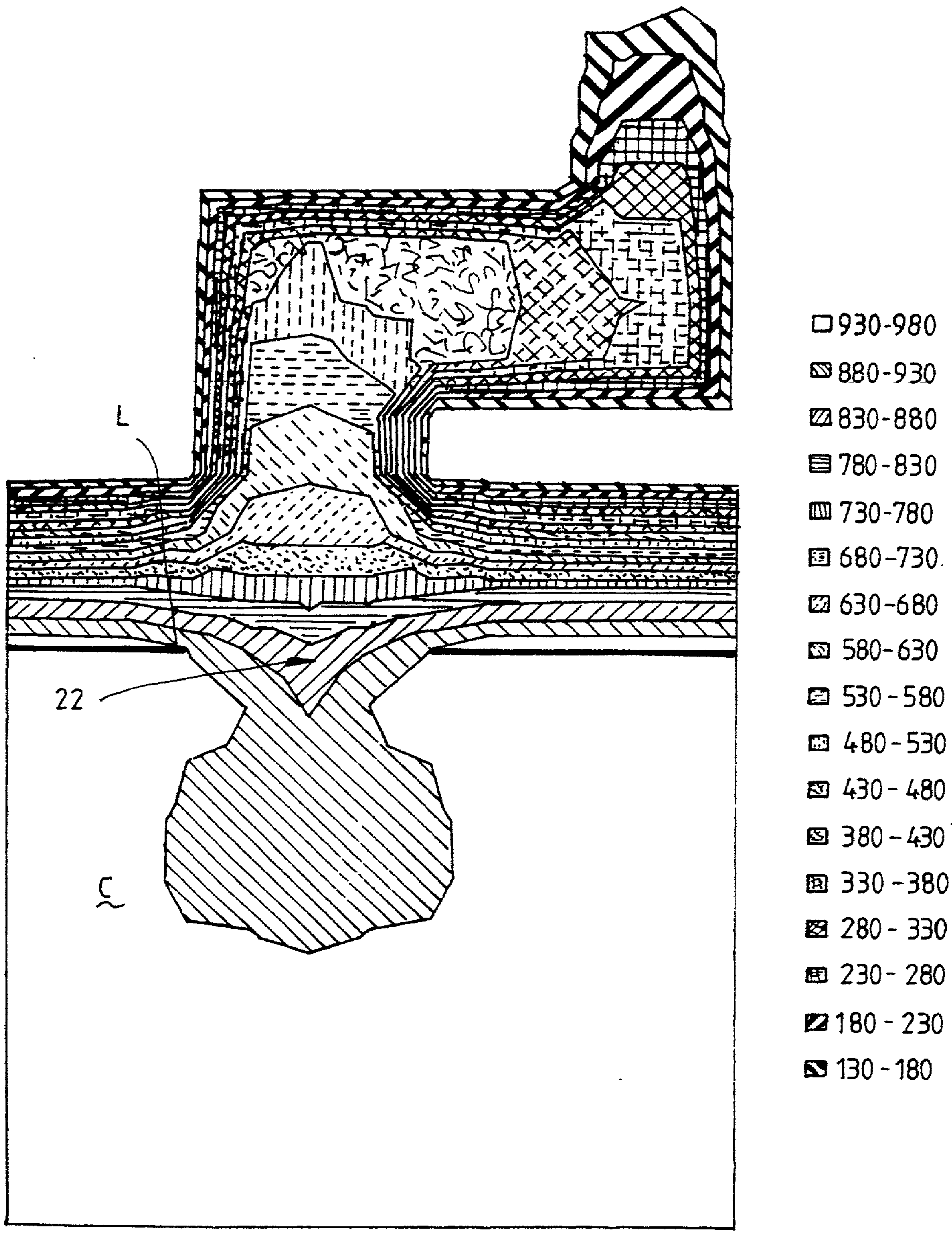
FIG. 5.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180-230
130-180

FIG. 6.

FOR UTILITY/DESIGN
CIP/PCT NATIONAL/PLANT
ORIGINAL/SUBSTITUTE/SUPPLEMENTAL
DECLARATIONS

RULE 63 (37 C.F.R. 1.63)
DECLARATION AND POWER OF ATTORNEY
FOR PATENT APPLICATION
IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

PW
FORM

As a below named inventor, I hereby declare that my residence, post office address and citizenship are as stated below next to my name, and I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the INVENTION ENTITLED ANODE ASSEMBLY

the specification of which (CHECK applicable BOX(ES))

X BOX(ES)
A. ☐ is attached hereto.
→ B. ☒ was filed on February 11, 2002 as U.S. Application No. /
→ → C. ☒ was filed as PCT International Application No. PCT/ AU00/00959 on August 11, 2000

and (if applicable to U.S. or PCT application) was amended on

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above. I acknowledge the duty to disclose all information known to me to be material to patentability as defined in 37 C.F.R. 1.56. Except as noted below, I hereby claim foreign priority benefits under 35 U.S.C 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT International Application which designated at least one other country than the United States, listed below and have also identified below any foreign application for patent or inventor's certificate, or PCT International Application, filed by me or my assignee disclosing the subject matter claimed in this application and having a filing date (1) before that of the application on which priority is claimed, or (2) if no priority claimed, before the filing date of this application:

PRIOR FOREIGN APPLICATION(S)

Number	Country	Day/MONTH/Year Filed	Date first Laid-open or Published	Date Patented or Granted	Priority NOT Claimed
PQ2188	Australia	13 August 1999			

If more prior foreign applications, X box *at bottom* and continue on attached page.

Except as noted below, I hereby claim domestic priority benefit under 35 U.S.C. 119(e) or 120 and/or 365(c) of the indicated United States applications listed below and PCT international applications listed above or below and, if this is a continuation-in-part (CIP) application, insofar as the subject matter disclosed and claimed in this application is in addition to that disclosed in such prior applications, I acknowledge the duty to disclose all information known to me to be material to patentability as defined in 37 C.F.R. 1.56 which became available between the filing date of each such prior application and the national or PCT international filing date of this application:

PRIOR U.S. PROVISIONAL, NONPROVISIONAL AND/OR PCT APPLICATION(S)

Application No. (series code/serial no.)	Day/MONTH/Year Filed	Status pending, abandoned, patented	Priority NOT Claimed

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

And I hereby appoint Pillsbury Winthrop LLP, Intellectual Property Group, telephone number (703) 905-2000 (to whom all communications are to be directed), and persons of that firm who are associated with USPTO Customer No. 909 (see below label) individually and collectively my attorneys to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith and with the resulting patent, and I hereby authorize them to delete from that Customer No. names of persons no longer with their firm, to add new persons of their Firm to that Customer No., and to act and rely on instructions from and communicate directly with the person/assignee/attorney/firm/ organization who/which first sends/sent this case to them and by whom/which I hereby declare that I have consented after full disclosure to be represented unless/until I instruct the above Firm and/or an attorney of that Firm in writing to the contrary.

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00909

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(1) INVENTOR'S SIGNATURE: Date: 6/5/2002

Name	Vjekoslav		JAKOVAC
	First	Middle Initial	Family Name
Residence	Victoria AUX	AUSTRALIA	AUSTRALIA
	City	State/Foreign Country	Country of Citizenship
Mailing Address	31 Kalbar Road, Research, Australia		
(include Zip Code)	Victoria, 3095		

200

(2) INVENTOR'S SIGNATURE: Date: 6/5/2002

Name	Vladimir		KANOVNIK
	First	Middle Initial	Family Name
Residence	Victoria AUX	AUSTRALIA	AUSTRALIA
	City	State/Foreign Country	Country of Citizenship
Mailing Address	2/55 Blackwood Street, Carnegie, Australia		
(include Zip Code)	Victoria, 3163		

☒ FOR ADDITIONAL INVENTORS see attached page.
☐ See additional foreign priorities on attached page (incorporated herein by reference).

Atty. Dkt. No. P290698
(M#)

DECLARATION AND POWER OF ATTORNEY
(continued)

ADDITIONAL INVENTORS:

(3) **INVENTOR'S SIGNATURE:** Drago Juric **Date:** 6/5/02

300

	Drago		JURIC
	First	Middle Initial	Family Name
Residence	Victoria AUX	AUSTRALIA	AUSTRALIA
	City	State/Foreign Country	Country of Citizenship
Mailing Address	6 Ben Nevis Grove, Bulleen, Australia		
(include Zip Code)	Victoria, 3105		

(4) **INVENTOR'S SIGNATURE:** **Date:**

	First	Middle Initial	Family Name
Residence			
	City	State/Foreign Country	Country of Citizenship
Mailing Address			
(include Zip Code)			

(5) **INVENTOR'S SIGNATURE:** **Date:**

	First	Middle Initial	Family Name
Residence			
	City	State/Foreign Country	Country of Citizenship
Mailing Address			
(include Zip Code)			

(6) **INVENTOR'S SIGNATURE:** **Date:**

	First	Middle Initial	Family Name
Residence			
	City	State/Foreign Country	Country of Citizenship
Mailing Address			
(include Zip Code)			

(7) **INVENTOR'S SIGNATURE:** **Date:**

	First	Middle Initial	Family Name
Residence			
	City	State/Foreign Country	Country of Citizenship
Mailing Address			
(include Zip Code)			

(8) **INVENTOR'S SIGNATURE:** **Date:**

	First	Middle Initial	Family Name
Residence			
	City	State/Foreign Country	Country of Citizenship
Mailing Address			
(include Zip Code)			

(9) **INVENTOR'S SIGNATURE:** **Date:**

	First	Middle Initial	Family Name
Residence			
	City	State/Foreign Country	Country of Citizenship
Mailing Address			
(include Zip Code)			

PTO/PCT Rec'd 16 MAY 2002

VERIFIED STATEMENT CLAIMING SMALL ENTITY STATUS (37 CFR 1.9(f) & 1.27(b)) - SMALL BUSINESS CONCERN

Applicant or Patentee: SRA Technologies Pty Ltd

Serial or Patent No: ____________________

Filed or Issued: ____________________

Title: Anode Assembly

I hereby declare that I am

☒ the owner of the small business concern identified below;
☐ an official of the small business concern empowered to act on behalf of the concern identified below

NAME OF SMALL BUSINESS CONCERN SRA Technologies Pty Ltd

ADDRESS OF SMALL BUSINESS CONCERN Suite G9, 62 Wellington Parade, East Melbourne, Victoria 3002, Australia

I hereby declare that the above identified small business concern qualifies as a small business concern as defined in 13 CFR 121.12, and reproduced in 37 CFR 1.9(d), for the purposes of paying reduced fees to the United States Patent and Trademark Office, in that the number of employees of the concern, including those of its affiliates, does not exceed 500 persons. For purposes of this statement, (1) the number of employees of the business concern is the average over the previous fiscal year of the concern of the persons employed on a full-time, part-time or temporary basis during each of the pay periods of the fiscal year, and (2) concerns are affiliates of each other when either, directly or indirectly, one concern controls or has the power to control the other, or a third party or parties controls or has the power to control both.

I hereby declare that rights under contract or law have been conveyed to and remain with the small business concern identified above with regard to the invention described in:

☒ the specification filed herewith with title as listed above
☐ the application identified above
☐ the patent identified above

If the rights held by the above identified small business concern are not exclusive, each individual, concern or organisation having rights in the invention must file separate verified statements averring to their status as small entities, and no rights to the invention are held by any person, other than the inventor, who would not qualify as an independent inventor under 37 CFR 1.9(c) if that person made the invention, or by any concern which would not qualify as a small business concern under 37 CFR 1.9(d), or a non profit organisation under 37 CFR 1.9(e).

Each person, concern or organisation having any rights in the invention is listed below:

☒ no such person, or organisation exists
☐ each such person, concern or organisation is listed below.

Separate verified statements are required from each named person, concern or organisation having rights to the invention averring to their status as small entities (37 CFR 1.27).

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlements to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 CFR 1.28(b)).

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that wilful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such wilful false statements may jeopardise the validity of the application, any patent issuing therein, or any patent to which this verified statement is directed.

NAME OF PERSON SIGNING VJEKOSLAV JAKOVAC

TITLE OF PERSON IF OTHER THAN OWNER GENERAL MANAGING DIRECTOR

ADDRESS OF PERSON SIGNING 31 KALBAR ROAD RESEARCH, AUSTRALIA

SIGNATURE __________ DATE 6/5/2002

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